succeeding section of this Report and Order the procedures that will apply to applicants in these circumstances and that we will follow to decide among the mutually exclusive applications.[70]

g. Inter-System Coordination

60. Several commenters also suggest that we institute formal, but not necessarily codified, procedures or guidelines for CDMA inter-system coordination in the context of adopting a domestic sharing plan. Some suggest that we use the initial sharing proposal submitted to the Negotiated Rulemaking Committee by the CDMA applicants as the basis for a domestic coordination framework. Indeed, the three CDMA applicants participating in the Joint Proposal agree to coordinate their systems in accordance with this framework expeditiously and in good faith.

61. We applaud the CDMA applicants for their good faith efforts to develop a framework for coordination. We have decided, however, not to incorporate these procedures in the Commission's rules. Historically, we have left domestic and separate international system inter-system coordination to the satellite licensees themselves, since they are in the best position to weigh the technical and economic trade-offs inherent in any coordination agreement.[71] This approach has proven successful. Since the CDMA applicants have represented that sharing is feasible, we expect that good faith efforts to resolve any outstanding coordination issues expeditiously in accordance with the Joint Proposal will commence after this Report and Order is issued. If the parties believe that any entity is not negotiating in good faith or if an impasse is reached on any issue, we will, upon request, become involved in the process and, if necessary, will devise a solution.

62. Another coordination issue raised by some of the commenters is whether and the extent to which a guardband is necessary between CDMA and TDMA/FDMA systems and, if so, which architecture should bear the burden. The parties to the Joint Proposal have agreed to develop an emissions mask between the CDMA and TDMA/FDMA band segments that spreads the burden between them. LQP, in contrast, suggests that an emissions mask may override the allocations made at WARC-92 because a mask will, in essence, protect Motorola's secondary downlink transmissions in the 1.6 GHz band.

63. We need not resolve this matter now. Rather, while we recognize that secondary services cannot, as a general matter, claim interference protection from harmful interference from

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[70] See paras. 88-97, infra.

[71] See, e.g., Hughes Communications Galaxy, Inc., 7 FCC Rcd 4672 (1992), at para. 8; GE American Communications, Inc. 3 FCC Rcd 6871 (1988), at para. 2; Assignment of Orbital Locations to Space Stations in the Domestic Fixed-Satellite Service, 50 Fed.Reg. 35228 (1985), at para. 19; RDSS Licensing Order, note 37, supra, at para. 19.

stations of a primary service,[72] we will leave the parties free to negotiate a guardband agreement once the technical parameters of their amended system proposals are finalized. If the parties negotiate an agreement that protects secondary operations, we will accept that solution. If the parties cannot agree, however, we will become involved and will look to the Table of Frequency Allocations to determine where any operational constraints are appropriately placed.

3. Plan If Mutual Exclusivity Is Not Resolved

64. We do not intend to continue our already-prolonged attempt to resolve this proceeding by compromise in the event that mutual exclusivity among the Big LEO applicants is not eliminated by amendments submitted by the November 16, 1994 filing deadline, as there is little reason to suppose that further pursuit of that elusive goal would be useful. In the Notice, we discussed three alternative procedures -- comparative hearing, lottery, and auction -- for resolving this proceeding in the event that the proposed sharing plan did not resolve mutual exclusivity and called for comment concerning the feasibility and/or legal availability of each of them. If an auction or lottery[73] was employed, we proposed to divide the spectrum into paired 2.0625 MHz uplink and downlink segments, with eight paired segments available for licensing. We proposed to limit each successful bidder or lottery winner to an award of up to four 2.0625 MHz paired segments, noting that this should provide ample spectrum to support a Big LEO system while allowing for at least two licensees.[74] We conclude that we can lawfully resolve this proceeding by means of an auction and that, of the three, an auction would better serve the public interest.

a. Comparative Hearing

65. We continue to believe that the prospect of delay in the initiation of service weighs heavily against use of a comparative hearing, particularly in light of the need for prompt participation by U.S. licensees in international coordination.[75] Whether conflict between Big LEO applications could be resolved through a comparative hearing in less time than is typically consumed in comparative hearings involving applications for broadcast licenses -- as TRW, the only commenter advocating use of comparative hearings as a fall-back procedure, contends -- is largely beside the point. Even under the most optimistic assumptions, selection of Big LEO licensees through a comparative hearing is likely to take considerably longer than the use of a lottery or competitive bidding.

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[72] See note 21, supra.

[73] Because the LEO applications were filed prior to July 26, 1993, the Commission is not statutorily prohibited from considering random selection as a licensing option. See Section 6002(e) of Pub.L. 103-66.

[74] Notice, note 2, supra, at para. 45.

[75] Id. at para. 40.

66. We also believe that a comparative hearing would be inadvisable for other reasons. The Commission has previously stated that comparative hearings would be inconsistent with our aim of affording flexibility to satellite licensees.[76] As a general matter, moreover, we are reluctant to substitute our judgment for the wisdom of the marketplace by dictating outcomes based on assessment of the relative merits of applicants' service proposals. We doubt whether we would be able to resolve all conflicts among LEO applications based on findings that certain of the applications are demonstrably technically superior to others. As previously noted, satellite design decisions involve complex trade-offs between engineering, marketing, and financial considerations, which are difficult to evaluate without reference to the functioning of the marketplace.[77] These design decisions are also modified to accommodate regulations, marketplace and financial constraints and uncertainties as these uncertainties become more clearly defined in time.

b. Lottery

67. Constellation is the only applicant that recommends use of a lottery in the event that we cannot accommodate all qualified applicants. It states that it favors this procedure only because it believes that auctions would create unacceptable international ramifications. LQP and TRW, in contrast, maintain that none of the factors listed in the Conference Report on Section 309(i) would support the use of a lottery procedure is present here.[78] LQP, Motorola, and TRW also contend that a lottery would be inappropriate because the pending applications involve technically diverse, non-fungible proposals. LQP and TRW argue that it would be unfair to the existing applicants, who have invested large sums of money in research and development for their proposals, to choose winners by the luck of the draw. TRW warns that a random selection process here would discourage planning and innovation by future applicants. Motorola objects that the results of a lottery would bear no relation to the best use of the available spectrum and would bestow insufficient spectrum or unusable combinations of spectrum-segments upon the winning applicants.

68. We will not use a lottery in this case because we have concluded that awarding Big LEO licenses through the use of competitive bidding procedures would better serve the public interest. Most importantly, an auction would be an economically efficient means of allocation. A well-designed auction produces an outcome approximating allocation to highest-valued use,

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[76] See Rules to Allocate Spectrum for Mobile Satellite Services, 6 FCC Rcd 4900, 4904 (1991), at paras. 19-20; and Rules to Allocate Spectrum for a Land Mobile Satellite Service, 2 FCC Rcd 485, 487 (1987), at para. 15.

[77] 2 FCC Rcd at 487, para. 15.

[78] See 47 U.S.C. § 309(i). See also H.R. Conf. Rep. No. 765, 97th Cong., 2d Sess, at 37 (1982).

which we believe promotes spectrum efficiency and other public interest considerations.[79] Use of competitive bidding procedures would provide participants with the incentive to conceive innovative, cost-effective and spectrum efficient uses for the spectrum-blocks to be assigned and to estimate accurately their potential commercial value. Further, a lottery may produce a haphazard outcome. Although such an outcome might be partially redressed through resale, that would entail further transaction costs. We do not believe that an auction would have significant adverse international ramifications, as discussed below.

c. Competitive Bidding

69. Legality. Having decided that it would best serve the public interest to use competitive bidding in the event that the sharing plan does not resolve mutual exclusivity, we next respond to arguments concerning our legal authority to do so. Section 309(j)(1) and (2) of the Communications Act, as amended, 47 U.S.C. § 309(j)(1), (2), permits auctions where mutually exclusive applications for initial licenses or construction permits are accepted for filing by the Commission and where the principal use of the spectrum will involve or is reasonably likely to involve the receipt by the licensee of compensation from subscribers in return for enabling those subscribers to receive or transmit communications signals.[80] TRW, however, asserts that "the entire thrust and substance" of the legislation authorizing the Commission to assign licenses by auction is "geared toward" licensing for the personal communication service (PCS) service and that the underlying legislative purposes "simply do not apply to . . . an inherently global . . . satellite service [for which] there are currently no more than six applications." However, nothing in Section 309(j) precludes the use of auctions for satellite services, and the scope of our Section 309(j) authority to use auctions clearly is not limited to PCS licensing.[81] Indeed, we have decided to use auctions for many services besides PCS.[82] Nor

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[79] Second Report and Order in the Implementation of Section 309(j) -- Competitive Bidding, 9 FCC Rcd 2348, 2361 (1994) (Implementation of Section 309(j), at para. 73. Moreover, an efficient auction would award licenses more quickly to those that value them most highly and would facilitate the efficient aggregation of interdependent licenses. We also note that the applicants here did not submit their proposals in reliance on an expectation that the Commission would use lotteries.

[80] No commenter disputes the holding in para. 42 of the Notice that Big LEO service will involve a "use of the electromagnetic spectrum" as defined in 47 U.S.C. §309(j)(2), notwithstanding that most of the applicants propose to provide service to resellers rather than end-users. As we noted previously, the legislative record indicates that it is irrelevant to the applicability of the 309(j)(2) definition whether a licensee's subscribers are end-users or resellers, and we believe that understanding is consistent with the plain meaning of the pertinent statutory text.

[81] The legislative record confirms that proponents of the legislation were well aware that it did not merely pertain to PCS licensing. See H.R. Report No. 103-111, 103d Cong., 1st Sess., at 256 (1993) ("[S]ection 309(j) is a generic statute that will govern the issuance of licenses in

does Section 309(j) withhold authority to use auctions for licensing international satellite systems or specify a minimum number of competing applications for a class of licenses that must be on file in order for licenses to be assigned by competitive bidding.

70. Constellation, Motorola and LQP contend that the statute forbids us from conducting an auction until we have used every means to attempt to eliminate mutual exclusivity. Motorola and LQP cite commentary in the House Report and in a letter from Congressman Dingell to then-Chairman Quello as evidence that Congress "clearly had the Big LEO proceeding in mind when it added this language to the bill" and that it believed that mutual exclusivity could be avoided in this proceeding. Further, TRW and COMSAT cite this commentary as proof that Congress enacted Subsection 309(j)(6)(E) to prevent the Commission from using an auction to assign Big LEO licenses.

71. Nothing on the face of Subsection 309(j)(6)(E), or in its legislative history, indicates that we are prohibited from granting Big LEO licenses by auction. The text of the Section merely provides that the Commission should continue to use techniques that avoid mutual exclusivity among applicants. Similarly, the commentary in the House Report states that it generally serves the public interest for the Commission to use engineering solutions and other mechanisms to avoid or eliminate mutual exclusivity and that the Commission should continue to do so in the Big LEO licensing proceeding. The Report does not assert, however, that if the Commission is unsuccessful in resolving mutual exclusivity, the legislation bars the Commission from auctioning Big LEO licenses. Rather, we construe the provision to mean that the Commission is obliged to attempt to eliminate mutual exclusivity. Indeed, if the Commission could avoid mutual exclusivity in every instance in which it arises, no need would exist for the Commission's auction authority. In the course of this proceeding, we have proposed several spectrum sharing plans to that end.[83] We do not think that it would serve the public interest to continue this effort in the event that the six applications before us, as amended in response to this Report and Order, are mutually exclusive.

72. Regardless of our general authority to conduct an auction in the Big LEO service, TRW contends that we may not auction the allocated 2.4 GHz band downlink frequencies because the pending applications for these frequencies are not mutually exclusive. According to TRW, all four applicants desiring to use the 2.4 GHz band could do so on a shared basis using the

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many different services"). See also Implementation of Section 309(j), note 79, supra.

[82] For example, auctions will be used to award licenses in the 900 MHz Specialized Mobile Radio Services and the Mutlipoint Distribution Services. See 47 C.F.R. § 1.2102(a).

[83] See, e.g., Committee Report, Addendum 1 (proposal developed by FCC Representative to the Committee that would have permitted all proposed systems to be licensed with some design modifications); Notice, note 2, supra, at para. 38.

CDMA technology that all of them propose.[84] Similarly, since the same four applicants are the only ones proposing to use the lower six MHz of 1.6 GHz band, TRW argues that we cannot use auctions to assign authorizations for that frequency range either. As TRW sees it, the only portion of the Big LEO spectrum that we can auction consistently with the mutual exclusivity proviso of Subsection 309(j)(1) is the sector of the 1.6 GHz band between 1616-1626.5 MHz, where both Motorola and the CDMA proponents have competing applications on file.

73. We do not agree with TRW that Subsection 309(j)(1) bars us from using an auction to award licenses for the lower portion of the 1.6 GHz band. There is simply not enough spectrum in the band to accommodate all pending applications. While we recognize that there are certain portions of the spectrum in which sharing among CDMA systems is possible (i.e., the 1610-1616 MHz and the 2483.5-2500 MHz bands), these frequencies cannot in themselves accommodate all proposed CDMA systems, including AMSC's. Consequently, these bands cannot be separated from the rest of the MSS frequencies in determining whether mutual exclusivity exists and whether auctions can be employed. Moreover, we are not proposing to conduct an auction until after the applicants have had an opportunity to amend their applications to conform with our rules. If our spectrum sharing plan does not then accommodate the systems of all qualified applicants, the plan will not be implemented. Rather, the 1.6 GHz band spectrum would be segmented and the qualified applicants will be required, in order to preserve their eligibility, to apply for a separate license for each segment that they want to use. Consistent with the mutual exclusivity prerequisite of Subsection 309(j)(1), In the event that only a single eligible application is filed for a particular segment within the filing window, the segment will be assigned to the applicant requesting it. We would not assign the license for a segment through competitive bidding unless two or more eligible applications for it were on file. Winners would be permitted to employ their choice of CDMA or TDMA/FDMA architectures.

74. We do agree with TRW that there is no need to assign 2.4 GHz band authorizations by competitive bidding. Because CDMA systems must use 1.6 GHz uplink and corresponding 2.4 GHz downlink frequencies to operate, we proposed in the Notice to pair 1.6 GHz and 2.4 GHz spectrum blocks for auctioning.[85] All applicants requesting authority to use the 2.4 GHz band concede that they can share it using CDMA technology, however. We therefore conclude that would be more appropriate to license all winners of auctioned 1.6 GHz spectrum blocks to operate in the space-to-Earth transmission direction in the 2483.5-2500 MHz band on a shared basis using CDMA techniques.

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[84] LQP contends, moreover, that segmentation of the 2.4 GHz band pursuant to the tentative auction plan outlined in the NPRM would be impracticable because any CDMA system would require use of all 16.5 MHz of the available 2.4 GHz band, whether it intends to share that spectrum in common with other CDMA systems or to use it exclusively.

[85] Notice, note 2, supra, at para. 45.

75. TRW contends that dividing sharable spectrum into segments and assigning a license for each segment to the highest bidder, as we proposed in the Notice, rather than assigning co-extensive licenses for the entire bandwidth to as many as could share it, would be "spectrum-inefficient" and therefore "manifestly contrary to the auction legislation." Constellation likewise asserts that assigning licenses for discrete segments of the Big LEO spectrum by competitive bidding would probably eliminate any chance of CDMA sharing, as auction winners would probably not consent to share use of their licensed segments with competing service providers. Constellation, accordingly, contends that such a licensing procedure would not promote efficient spectrum use. Similarly, LQP asserts that assigning Big LEO licenses by auction would deter multiple entry and competition.

76. We do not agree that auctioning the 1.6 GHz band in band segments would disserve the statutory objectives of promoting competition and efficient spectrum use. First, it is not clear that using an auction licensing mechanism would discourage spectrum sharing. Applicants who obtain licenses for band segments by competitive bidding could negotiate post-auction sharing agreements among themselves and request license modifications, as TRW acknowledges in its comments.[86] If, in fact, the potential economic value of some or all of the available 1.6 GHz band could best be realized through frequency sharing, licensees will have an incentive to enter into such mutually beneficial sharing agreements, no matter how they acquire their licenses. Second, there is no evident reason to conclude that competitive bidding would impede competition. Our auction rules will ensure that there will be at least two providers. Further, by dividing the available bandwidth into relatively small segments and allowing bidders to acquire several segments and aggregate them, the number of initial licensees and the amounts of spectrum held by particular licensees will be determined largely by market forces.

77. We recognize it is possible that an auction might result in fewer licensees than could otherwise have been accommodated using a sharing plan. As discussed above, however, we have been unable to develop a sharing plan that avoids mutual exclusivity, assuming all applicants are deemed qualified. If mutual exclusivity cannot be avoided by sharing, implementing an auction may achieve countervailing public interest benefits. As we have explained, assigning spectrum rights to those who place the highest value on them generally serves the public interest because it ensures an award to the highest-valued use.

78. We do not agree with LQP that using auctions is contrary to our established policy of favoring multiple entry in new satellite services. We have ensured that our competitive bidding framework will result in at least two licensees, thereby ensuring the benefits of a competitive market structure.[87] Moreover, insofar as our policy permits marketplace incentives

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[86] TRW Comments at 102-103.

[87] See para. 89, infra.

to determine the number of service providers, the policy is fully consistent with our "open skies" satellite policy, which was based on similar considerations.[88]

79. TRW also suggests that we may not lawfully use an auction to assign Big LEO licenses because of the statutory mandate concerning promotion of economic opportunity. TRW claims, for instance, that the statute requires the Commission, consistent with the public interest and the characteristics of the proposed service, to "prescribe ... bandwidth assignments that promote ... economic opportunity for a wide variety of applicants" (emphasis added),[89] which is impossible here given the number of Big LEO licenses that can be awarded. TRW further asserts we cannot meet the statute's requirements to afford opportunity for small businesses, businesses owned by members of minority groups or women, and rural telephone companies, since there are no representatives of those "designated entity" (DE) classes among the existing applicants, that it is virtually impossible for a company qualifying as a small business to raise enough capital to finance construction and operation of a Big LEO system, and that it would be a daunting task to devise a system of viable set-asides for designated entities without drastically impairing the ability of other applicants to implement service.

80. Subsection 309(j)(3) requires the Commission to seek to promote "economic opportunity and competition," among other goals, "by disseminating licenses among a wide variety of applicants, including [DEs]," and Subsection 309(j)(4)(D) directs us to ensure, when prescribing regulations governing auction procedures or eligibility to apply for licenses to be assigned by auction, that DEs are given an opportunity to participate in the provision of spectrum-based services. The statute, however, directs the Commission, in specifying auction procedures, to pursue other objectives, aside from ensuring opportunity for DEs. Among these are the goals of promoting "the development and rapid deployment of new technologies, products, and services for the benefit of the public, including those residing in rural areas, without administrative or judicial delays" and of promoting "efficient and intensive use of the electromagnetic spectrum." 47 U.S.C. § 309(j)(3). In the Notice, we tentatively concluded auctions would further these objectives and we affirm these conclusions in this Report and Order.[90] The statute also implicitly leaves it to the Commission to strike a balance in the public interest among the statutory objectives.[91] Here, only six applications are being considered. No one disputes TRW's assertion that none of the applicants qualifies as small, minority-owned or women-owned.[92] It therefore would appear that to disseminate Big LEO licenses to DEs we

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[88] Domestic Communications Satellite Facilities, 22 FCC 2d (1970), 35 FCC 2d 844 (1972), recon. in part, 38 FCC 2d 665 (1972) (DOMSAT I, II, and III, respectively).

[89] 47 U.S.C. § 309(j)(4)(c).

[90] See Notice, note 2, supra, at para. 43.

[91] See Implementation of Section 309(j), note 79, supra, at para. 74.

[92] See Docket 93-253 for criteria.

would have to open a new filing window for Big LEO applications.[93] While in some circumstances it might be feasible to take such an approach, we believe that it is not the case here. To ensure that this needed service is made available as quickly as possible, particularly to rural residents not otherwise served by the telecommunications infrastructure, and to preserve the opportunity for the United States to continue its leadership role in promoting global development through an enhanced global information infrastructure, we are committed to awarding licenses by January 31, 1995.[94] Opening a new filing window would make that goal impossible. Potential new applicants would need a reasonable amount of time, traditionally three months from the date of publication in the Federal Register, in which to develop and submit system proposals.[95] Opening a new filing window also would be inequitable to the pending applicants, who filed their proposals well before Section 309(j) was enacted and who have spent considerable time and expense participating in this proceeding. In light of these considerations, we believe that an auction to award Big LEO licenses is an appropriate exercise of our discretion.

81. Other considerations. In the Notice, we recognized that although auctions appear advantageous for many reasons, the approach might have unintended consequences internationally. In particular, we noted that other countries may look to our lead in imposing these costs on Big LEO systems.[96] Given the number of countries that may be served by Big LEO systems, we stated that these costs may be considerable and may preclude a U.S.-owned system from serving other countries. We noted, however, that these costs may not in fact be significant in countries that seek to ensure that voice MSS is available within its borders. We further noted that applicants will pay no more than that which they determine is consistent with their expected revenues from providing service in that country. Nevertheless, we recognized that the international nature of the Big LEO service raises concerns that are not applicable to the domestic-only services for which auctions are implemented and requested comment on this issue.

82. Motorola, Constellation, LQP, TRW, and COMSAT all contend that an auction is inadvisable because it would set a bad example for foreign governments. If foreign governments were to use auctions to assign spectrum rights, they maintain, the cost of providing global MSS would be driven up, possibly to such an extent that Big LEO operators would be unable to provide worldwide service. TRW asserts that the consequent cost increases might deter most potential entrants, to the impairment of competition, or might even make it infeasible for anyone to provide Big LEO service. COMSAT speculates that foreign governments might conduct auctions in a manner that places U.S. companies at a disadvantage.

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[93] DEs can, of course, participate in the Big LEO industry by leasing space segment capacity, by manufacturing user handsets, or by offering services to end users.

[94] See also note 6, supra.

[95] See NVNG MSS Order, note 48, supra. See also RDSS Licensing Order, note 37, supra, where licensee was given six months to amend its applications to conform to rules as adopted.

[96] Notice, note 2, supra, at para. 44.

83. The comments have provided no concrete evidence, however, that an auction would have these harmful effects. We have concluded elsewhere that, as a general matter, the public interest is served by awarding licenses to those who assign the highest value to them.[97] In light of these substantial public interest benefits, the commenters' mere recitals of the concerns we raised in the Notice do not persuade us that auctions are inadvisable.

84. We doubt, first, that our choice of licensing method for the Big LEO service will determine foreign licensing practices as much as the commenters predict. Foreign officials already know that we recently obtained a statutory mandate for assigning spectrum licenses by competitive bidding and have decided to assign licenses of enormous aggregate commercial value for a variety of new services by that means. We assume that those responsible for assigning spectrum rights in other countries will conduct spectrum auctions if that would best serve the interests that they are obliged to promote, regardless of what we choose to do in this proceeding. Further, even if auctions are implemented, applicants will bid no more at an auction than that which they determine is economically feasible.

85. Conversely, TRW contends that if we assign Big LEO licenses at auction and foreign authorities issue such licenses to others free of charge, the U.S. licensees would be at a competitive disadvantage in the global market. Constellation similarly maintains that by assigning the licenses at auction the Commission "would create an incentive for U.S. companies to develop LEO technology through foreign based systems that did not have to spend significant amounts of capital for operating licenses." TRW also contends that companies who purchase MSS licenses in the United States at auction might encounter unfair competition from INMARSAT because the INMARSAT Convention and the Communications Satellite Act might be construed to require that COMSAT be allowed to access INMARSAT capacity from the U.S. without paying for spectrum use.

86. We do not believe the prospect that auctions will be conducted only in the United States would disadvantage U.S. licensees globally. We have not yet decided whether, and the terms on which, foreign providers, including INMARSAT, will be able to provide domestic service. We envision that reciprocal bilateral arrangements on a country-by-country basis will be negotiated. In reaching and implementing these arrangements, we will consider at that time whether foreign entities not subject to U.S. auctions would have the economic incentive and ability to offer domestic service at significantly lower rates than Big LEO operators who purchased spectrum. Further, under this scenario, both U.S. operators and foreign operators appear able to receive licenses free of charge in a foreign country. We fail to see how this would put U.S. operators at a "global disadvantage." Finally, contrary to Constellation's argument, we see no reason to suppose that applicants who could compete successfully as providers of Big LEO service in the U.S. market would lose interest in developing systems in the United States merely because it would be necessary to purchase licenses. If it would be undesirable to serve the U.S.

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[97] Implementation of 309(j), note 79, supra, at paras. 73-74 and n.65.

market at high spectrum prices, the prices paid at an auction should fall until serving the U.S. market is commercially desirable.

87. Consequently, we conclude that we have the statutory authority to award Big LEO licenses through an auction process. We will implement competitive bidding procedures in the event that all six pending applicants file amendments on November 16, 1994 that meet all requirements, including financial requirements, for the Big LEO service, but their applications are still mutually exclusive.[98] We place applicants on notice that if an auction needs to be held it will be scheduled as quickly as possible. Given the importance of proceeding with Big LEO licensing, preparation time for the applicants will necessarily be circumscribed.

d. Competitive Bidding Procedures

88. Segmentation. As proposed in the Notice, we will divide the 1.6 GHz band spectrum into eight 2.0625 MHz segments.[99] We recognize that Constellation and LQP assert that a 2.0625 MHz block is "unworkable" because it is inconsistent with some of the applicants' channelization plans, which proposed 1.25 MHz channels. Further, LQP asserts that any auction of discrete bandwidth segments within the 1.6 GHz band would inevitably result in some applicants getting unusable, disjointed spectrum blocks. We do not believe these concerns warrant a change in the proposed spectrum blocks. First, two of the six applicants do not propose to use 1.25 MHz channels. Moreover, any anomalies in spectrum awards can be corrected in post-auction transactions, as we intend (as explained infra) to allow the licensees to aggregate and disaggregate spectrum through resale.

89. Bandwidth cap. To ensure that there are at least two Big LEO providers, we will not permit any applicant to acquire more than four 2.0625 MHz band segments in the 1.6 GHz band, i.e., no more than 8.25 MHz, at auction.[100] We would also deny permission for a post-auction transaction that would result in an accumulation in excess of that limit in the absence of a compelling showing of justification for a waiver.

90. Competitive Bidding Design. In determining the procedures to be employed if an auction of Big LEO licenses is necessary, we are guided by the principles developed in PP

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[98] If some applicants defer their financial showings as described in para. 13, supra, all deferred applications may not be able to be granted. If, at that time, we have issued some licenses, we will not implement the auction procedure described below, which assumes that none of the MSS spectrum has been assigned, to choose among the mutually exclusive deferred applications. Rather, as noted, we will develop another processing procedure at that time.

[99] As discussed in the Notice, it appeared that as little as 2.0 MHz of spectrum could provide an individual CDMA system with the same capacity as it would have operating on a shared basis over 11.35 MHz of spectrum. See Notice, note 2, supra, at para. 45.

[100] See Notice, note 2, supra, at para. 45.

Docket No. 93-253, the proceeding instituted to implement Section 309(j) of the Communications Act. The Second Report and Order in that proceeding[101] established the criteria to be used in selecting the auction design method to use for each particular auctionable service. The Commission received voluminous comment on auction design issues. Generally, we concluded that awarding licenses to those parties who value them most highly will foster Congress's policy objectives. In this regard, we noted that since a bidder's ability to introduce valuable new services and to deploy them quickly, intensively, and efficiently increases the value of a license to that bidder, an auction design that awards licenses to those bidders with the highest willingness to pay the most tends to promote the development and rapid deployment of new services and the efficient and intensive use of the spectrum. In articulating our auction design principles we agreed with the weight of the comments in that proceeding -- many of which were supported by academic auction design experts -- that: (1) licenses with strong value interdependencies should be auctioned simultaneously; (2) multiple round auctions generally will yield more efficient allocations of licenses and higher revenues, especially where there is substantial uncertainty as to value because they provide bidders with information regarding other bidders' valuations of licenses; and (3) since they may be relatively expensive to implement and time-consuming, simultaneous and/or multiple round auctions may become less cost-effective as the value of licenses decreases.[102]

91. Based on the foregoing, we concluded that where the licenses to be auctioned are interdependent and their value is expected to be high, simultaneous multiple round auctions would best achieve the Commission's goals for competitive bidding.[103] We indicated that compared with other bidding mechanisms (such as sequential and sealed bid auctions), simultaneous multiple round bidding will generate the most information about license values during the course of the auction and provide bidders with the most flexibility to pursue back-up strategies. Thus, we concluded that simultaneous multiple round bidding is most likely to award interdependent licenses to the bidders who value them most highly. We also indicated that this method will facilitate efficient aggregation of licenses across spectrum bands, thereby resulting in vigorous competition among several strong service providers who will be able rapidly to introduce a wide variety of services highly valued by end users.[104] In addition, we concluded that because of the superior information and flexibility it provides, this method is likely to yield greater revenues than other auction designs. Thus, we found that the use of simultaneous multiple round auctions would generally be preferred.[105]

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[101] Note 79, supra.

[102] Id. at para. 69.

[103] Id. at paras. 109-111.

[104] Id. at para. 106.

[105] Id.

92. Because, however, simultaneous multiple round bidding is likely to be more administratively complex and costly both for bidders and for the FCC than sequential or single round bidding, we indicated that we would use this auction design only where license values are interdependent and the expected value of the licenses to be auctioned is high relative to the costs of conducting a simultaneous multiple round auction.[106]

93. If it becomes necessary to employ competitive bidding procedures to award Big LEO licenses, we will conduct a single simultaneous multiple round auction to award licenses in those 2.065 MHz bands for which two or more applications have been filed.[107] Each of the characteristics that lead to selection of this auction design are present here. We expect that there will be a high degree of interdependence in the values of Big LEO licenses. Licenses may be interdependent either because they are substitutes or because they are worth more as part of a package than individually. We would expect there to be some substitutability among these licenses. There may be important ways in which they might be complements as well. Though all will be nationwide licenses, a single entity will be able to aggregate up to four licenses. It is reasonable to assume that the value that a bidder places on one license will to at least some degree depend upon whether it will be able to acquire other licenses. We also expect that the value of Big LEO licenses will be high relative to the costs of conducting a simultaneous multiple round auction, in part because as the Commission gains experience with simultaneous multiple round auctions, the costs associated with of implementing them may fall.

94. Procedural, Payment and Penalty Issues. Through our July 1994 auction of nationwide licenses to provide Personal Communications Services in the 900 MHz band (narrowband PCS), we have gained some experience with simultaneous multiple round auctions. It appears that the rules we adopted concerning the procedures to be used in conducting auctions, the schedule for payment for licenses, and the penalties to be paid for bid withdrawal, default or disqualification, have worked well.[108] In the event that it becomes necessary to employ competitive bidding in Big LEO licensing, we will conduct auctions as specified under those rules. If such an auction is required, we will issue a Public Notice explaining further the administrative details of the auction, but we generally expect the auction will be conducted similarly to the nationwide narrowband PCS auction.

95. In order to reduce the risk of defaults and to ensure that the Commission has a ready source of funds to satisfy any bid withdrawal or default penalties, we will impose a requirement that, to be qualified to participate in the Big LEO auction, applicants must submit

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[106] Id. at paras. 110-111.

[107] See para. 73, supra.

[108] See Sections 1.2104-1.2109 of the Commission's Rules, 47 C.F.R. §§1.2104-1.2109.

an upfront payment to the Commission prior to the auction.[109] Consistent with our auction rules for Personal Communications Services, we have decided to set the upfront payment at approximately two cents per MHz of spectrum per person residing in the proposed service area ($0.02 per MHz-pop).[110] Because Big LEO systems must be able to provide service to all areas of the fifty states, $0.02 per MHz-pop would amount to approximately $10 million per 2.0625 MHz segment.[111] For simplicity, we will round this to the nearest million, and require an upfront payment of $10 million.

96. Resale, aggregation and disaggregation. Aside from imposing the 8.25 MHz cap on aggregation, we will not restrict auction winners from reselling 1.6 GHz band spectrum-rights. They would be free not only to resell 2.065 MHz segments but also to reassign any smaller portion of 1.6 GHz band spectrum. Affording such flexibility enhances beneficial incentives.[112] Although we do not think that such post-auction transactions would be likely to entail unjust enrichment,[113] applications for consent to assignment of Big LEO spectrum authorizations obtained by auction will be subject to the disclosure and close-scrutiny policies delineated in the Second Report and Order in the auction rulemaking.[114]

97. Assignment of 2.4 GHz band. As previously noted, all auction winners will be authorized to operate over the entire 2483.5-2500 MHz band, with the stipulation that operation in that band must be in the CDMA mode and must be used for downlink transmissions.

**B. Interservice Sharing**

98. In the Notice, we recognized that Big LEO systems will be required to share the 1.6/2.4 GHz and adjacent frequency bands with a number of existing services. In the 1.6 GHz range, the 1610-1626.5 MHz band is allocated to the aeronautical radionavigation service (ARNS) on a co-primary basis, and a segment of the band, at 1610.6-1613.8 MHz, is allocated to the radioastronomy service (RAS) on a co-primary basis. In the 2.4 GHz range, the 2483.5-2500 MHz band is allocated for co-primary use by the broadcast auxiliary service, by the terrestrial

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[109] The upfront payment will be fully refunded to unsuccessful bidders who are not subject to bid withdrawal or default penalties.

[110] See Implementation of Section 309(j), note 79, supra, at para. 169 and 47 C.F.R. § 1.2106.

[111] I.e., .02 x 2.0625 x [U.S. pop.]

[112] Of course, parties to such transactions must comply with 47 U.S.C. § 310(d) by filing applications for consent to assignment.

[113] See Implementation of Section 309(j), note 79, supra, at paras. 211-12.

[114] Id. at para. 214.

fixed-service and by industrial, scientific and medical (ISM) operations. Adjacent bands are allocated to the aeronautical radionavigation satellite service, the instructional television fixed service (ITFS) and the multi-channel multi-point distribution service (MMDS).

99. The Negotiated Rulemaking Committee was comprised of Big LEO applicants and representatives of most parties potentially affected by Big LEO services, and analyzed extensively interservice sharing at 1.6/2.4 GHz. We used the Committee's recommendations as the primary basis the proposals in our Notice. We sought comment on those proposals as well as on those areas where a representative of an affected interest did not participate in the Committee, or where the Committee could not reach a consensus on an interservice sharing issue.

1. Radio Astronomy Service

100. As noted above, the 1610.6-1613.8 MHz frequency band is allocated to the RAS on a co-primary basis.[115] RAS operations involve the reception of radio waves of cosmic origin,[116] and are responsible for amassing a substantial portion of information about the universe that has been acquired in the last sixty years. Because the RAS involves only radio reception, it cannot interfere with other services operating in the same frequency band. However, it can receive harmful interference from other services. As a co-primary service, the RAS is entitled to protection from harmful interference. Ensuring this protection is complicated by the nature of cosmic radiation emissions, which are similar to random noise emissions and have extremely low power flux density levels at the Earth. Further, there is a potential for both in-band and out-of-band interference.[117]

a. In-band interference to the RAS

101. The Committee was able to agree on procedures that would permit sharing between Big LEOs and the RAS. The Committee's task was made somewhat easier by the fact that radio astronomy observations are usually conducted in remote areas and are not always continuous. The Committee's proposal, developed cooperatively with the Committee on Radio Frequencies

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[115] The 4990-5000 MHz band is also allocated to the RAS on a primary basis. Second harmonic spurious emissions from 2.4 GHz MSS operations could cause interference to RAS in that band. See paras. 120-121, infra.

[116] See international Radio Regulations 55 and 14.

[117] An out-of-band emission is radio frequency energy, located on a frequency or frequencies immediately outside the necessary bandwidth, that result from the modulation process. This does not include spurious emissions, which may be reduced without affecting the corresponding transmission of information. See 47 C.F.R. § 2.1.

(CORF),[118] would establish fixed-radius protection zones around the sixteen radio astronomy sites in the United States and technical requirements for MSS downlink transmissions. Based on this recommendation, we proposed to establish protection zones around radio astronomy sites in the United States as a means of preventing MSS transmissions from interfering with RAS observations in the 1610.6-1613.8 MHz band.[119] To that end, we also proposed that "all 1.6/2.4 GHz MSS systems shall be capable of determining the position of MSS user transceivers accessing the space segment through either internal radiodetermination calculations or external sources such as LORAN-C or GPS." [120]

102. Big LEO parties generally agree with the fixed-radius protection zone approach. However, both TRW and Constellation question whether it is necessary to require all MSS systems to be capable of determining the position of their user terminals.[121] They contend that a position location requirement need not be imposed on those MSS systems that elect to use beacon-actuated protection systems as a means for avoiding harmful interference to RAS observations.

103. As we stated in the Notice, the Committee decided that a beacon actuated protection system might provide an alternative to fixed radius protection zones. Under such a system, a beacon would transmit a signal when RAS observations were in progress. Upon receipt of this signal, an MSS control center would automatically assign the MSS terminal to a communications channel outside of the shared MSS-RAS frequency band. The Committee concluded, however, that several theoretical and practical concerns must be addressed before a beacon system can be implemented.[122] CORF continues to support that position.[123]

104. Because beacon actuated protection systems are not yet fully developed, we will adopt our original proposal that requires MSS operators to protect RAS observations in the 1610.6-1613.8 MHz band using the fixed-radius protection zone method. Nevertheless, because we expect that more efficient solutions will be developed, we will permit MSS licensees to use smaller geographic protection zones in lieu of the specified areas upon a showing that MSS operations will not cause harmful interference to an RAS observatory during periods of

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[118] CORF operates under the auspices of the National Academy of Sciences and is responsible for advancing the interest of radio astronomy in the United States.

[119] See proposed Section 25.213(a)(1)(i)-(iii).

[120] See proposed Section 25.213(a)(1).

[121] TRW Comments at 120, Constellation Reply at 43.

[122] Notice, note 2, supra, at n.90.

[123] CORF Reply Comments at 4.

observation.[124] We will, however, as proposed, allow beacon-actuated protection zones to be used in lieu of fixed protection zones if a coordination agreement is reached between a mobile-satellite system licensee and the Electromagnetic Spectrum Management Unit (ESMU) on the specifics of beacon operations."[125] Should any of the Big LEO licensees show at a later time, and coordinate with the ESMU, that certain other methods can be used in lieu of the fixed-radius protection zone, we will allow MSS system operators to employ these methods. In the interim, however, position determination of MSS user transceivers is necessary to accomplish fixed-radius zone protection. Therefore, we adopt as part of Section 25.213(a)(1), the MSS user transceiver position determination requirement as proposed in the Notice.

105. In the Notice, we also proposed that MSS user transceivers be capable of terminating operations as soon as practicable upon entering an RAS protection zone.[126] LQP argues that our proposal would require that calls initiated outside of an RAS protection zone be terminated as soon as the MSS user transceiver moves within the protection zone, which, according to LQP, would be inordinately complex and costly.[127] LQP suggests that our rules should permit the call to be switched successfully to frequencies outside of the RAS bands (during RAS observations) before operations are terminated to that unit.[128]

106. We believe that LQP's suggestion is reasonable. Allowing calls initiated prior to entering an RAS protection zone to continue until a non-RAS frequency is found will ensure continuity of service to the MSS user. Further, we believe that other requirements that we are adopting, such as the notification requirement that is described below, will ensure that RAS operations are not affected adversely. Therefore, we modify proposed Section 25.213(a)(1)(v) as suggested by LQP.

107. We also proposed in the Notice to require that the ESMU notify MSS licensees in the 1610.6-1613.8 MHz band of radio astronomy observations.[129] This requirement was proposed to ensure that MSS operations terminate as soon as possible after an MSS user transceiver enters a RAS protection zone where observations are being made. CORF suggests that it could meet this requirement by providing MSS operators with schedules of RAS

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[124] See Section 25.213(a)(1)(v).

[125] See Section 25.213(a)(1)(vii). The ESMU falls under the auspices of the National Science Foundation and is responsible for coordinating RAS frequencies.

[126] See proposed Section 25.213(a)(1)(v). Notice, note 2, supra, at para. 50.

[127] LQP Reply at 58.

[128] LQP Comments at 64.

[129] See proposed Section 25.213(a)(1)(v).

observations.[130] TRW disagrees, stating that CORF should be required to provide notification "of periods of actual radio astronomy observations rather than a general schedule."[131] We agree with TRW that it would not be overly burdensome for the ESMU to notify the small number of licensed in-band Big LEO operators of periods of actual RAS observations. This will help ensure that no interference is caused to RAS observations in the event that a schedule is changed.

108. In a related matter, Motorola notes that the Committee suggested that RAS observations not be scheduled during peak MSS/RDSS traffic periods to the extent possible.[132] CORF does not object to this proposal.[133] RAS observations are usually carried out in remote areas and are not continuous. Even during peak MSS traffic periods, the majority of MSS traffic should not occur in RAS observation areas. We do not therefore believe that adherence to this provision will be burdensome to RAS. Consequently, we include this provision in our rules in Section 25.213(a)(4).

109. Finally, TRW requests that we agree to solicit public comment before we require MSS systems to protect additional RAS sites beyond the sixteen sites specified in the rules.[134] In bands shared by two or more services on a co-primary basis, new facilities in either service must be coordinated among affected operators. As provided for in proposed rule Section 25.213(1)(a)(viii), which we adopt, we will solicit comment with respect to protection from additional RAS sites.

b. Out-of-band interference to RAS from primary MSS uplinks at 1.6 GHz

110. In the Notice, we also recognized that MSS uplink operations in the 1613.8-1626.5 MHz portion of the band could cause unacceptable out-of-band interference into RAS operations at 1610.6-1613.8 MHz. We also noted the Committee's suggestion to establish fixed protection zones similar to, but smaller than, those recommended for in-band emissions, although we did not propose a rule in this regard.[135]

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[130] CORF Comments at 4-5.

[131] TRW Reply Comments at 72.

[132] Motorola Comments at 55, n. 41.

[133] Specifically, CORF supports insertion of the following text in the rules: "The RAS shall avoid scheduling radio astronomy observations during peak MSS/RDSS traffic periods to the greatest extent practicable." See CORF Reply at 2.

[134] Proposed Section 25.213(a)(1)(vii).

[135] Notice, note 2, supra, at para. 51.

111. CORF suggested several alternatives to our proposals:[136]

(1) to require that the power flux density (pfd) level reaching RAS sites from a mobile user terminal operating anywhere in the 1610-1626.5 MHz band not exceed the pfd from a mobile user terminal operating within the RAS 1610.6-1613.8 MHz band segment at the edge of the protection zone applicable for that site, or

(2) to prohibit mobile terminal operations within the 1613.8-1615.8 MHz band during RAS observations within protection zones of 100 km or 30 km around RAS sites depending upon the type of observatory involved. [137]

112. The MSS parties generally oppose restrictions on out-of-band emissions for the purpose of protecting RAS. For example, Constellation argues that MSS out-of-band levels should not be unilaterally defined by the radio astronomy community without any regard to the impact those levels would have on other services.[138] TRW states that it could agree to CORF's suggestions if a compliant mobile user terminal were not required to undertake further coordination with the RAS. TRW notes, however, that CORF's out-of-band protection proposals would relegate MSS to co-primary or even lower status in frequency bands that are not allocated to the RAS."[139] Only LQP generally agrees with CORF's suggestion. According to LQP, there is sufficient 1.6 GHz band spectrum to switch MSS users near RAS sites from potentially interfering channels to channels separated from RAS observations.[140]

113. We have considered the impact of this proposal on Big LEO licensees and conclude they would not be unduly burdened by protecting RAS observations from out-of-band MSS emissions. It appears that less than one percent of the MSS consumer use would be affected by CORF's alternative proposals for protecting RAS from out-of-band MSS emissions.[141]

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[136] See CORF Comments at 3-4.

[137] Radio astronomy observatories use two types of antennas. Observatories with a very long baseline array (VLBA) use interconnected radio telescopes that are dispersed in widely separated locations. Due to the geographic separation of the telescopes, the chance of correlated interference from any single mobile earth terminal is small. Consequently, VLBA sites are not as susceptible to interference as are observatories using a single radio telescope. Eleven of the 16 radio astronomy sites in the U.S. are VLBA sites and they require relatively smaller protection zones than non-VLBA sites.

[138] Constellation Comments at 47.

[139] TRW Reply at 71.

[140] LQP Reply Comments at 57, Reply Tech Appendix at 2.1.

[141] CORF Reply Comments at 8.

Further, those affected would not be denied communications. They would simply be assigned to another uplink channel by the MSS network control center. We do not believe that the CORF proposals relegate the MSS to co-primary or even lower status. The RAS is seeking protection in bands only in the 1610.6-1613.8 MHz band, which is allocated to the RAS. Therefore we adopt CORF's proposals to protect RAS, during observations, from out-of-band emissions caused by Big LEO systems. If Big LEO operators cannot meet the power density levels necessary to protect RAS from harmful interference, we will require that Big LEO operations be terminated within the protection zones specified in Section 25.213(a)(1)(iii).

c. Out-of-band interference to RAS from secondary downlinks in the 1.6 GHz band

114. In the Notice, we proposed to codify the Committee's recommendations to eliminate potential harmful out-of-band interference to RAS from secondary MSS downlinks operating at 1613.8-1626.5 MHz.[142] The Committee recommended that such operations be restricted to frequencies separated by the upper edge of the RAS band by at least 2.2 MHz, that MSS downlink emissions be filtered aboard the spacecraft, that frequencies be selectively controlled and that an analysis and testing program be conducted in cooperation with the radio astronomy community. Based on its deliberations, the Committee proposed that we adopt rules governing use of the 1613.8-1626.5 MHz band that limit out-of-band emissions so that they do not exceed -238 dB(W/m$^2$/Hz) during observations at non-VLBA sites and -198 dB(W/m$^2$/Hz) during observations at VLBA sites.

115. Motorola argues that the limits proposed in the Notice are too rigid and would unduly constrain MSS operations.[143] In support, Motorola contends that those limits were devised originally using assumptions that are not applicable to Big LEO operations. For example, Motorola notes that the calculations assumed an immobile, continuous interference source, whereas secondary MSS downlink LEO operations would present an intermittent source. Further, Motorola notes that although the Committee reached a consensus on a recommendation regarding limits, it did not agree on a proposed rule to govern Big LEO MSS operations. Motorola asserts that instead of adopting specific protection limits applicable to MSS secondary downlinks, the Commission should only restate the general obligation that secondary services not cause harmful interference to primary services.

116. LQP and TRW disagree with Motorola. LQP states that our proposal is reasonable and should be adopted.[144] TRW asserts that Motorola's proposal does not adequately consider the needs of the RAS. It states, however, that if secondary downlinks are limited to the

[142] Notice, supra note 2, at para. 51; see also proposed Section 25.213(a)(2).

[143] Motorola Comments at 54.

[144] LQP Reply at 59-60.

1621.35-1626.5 MHz band, thereby creating a 7.5 MHz guardband between RAS and secondary MSS, Motorola's proposals would be acceptable.[145]

117. We recognize the need to protect RAS observations from secondary MSS downlink operations. At this juncture, however, we need not consider specific limits on Big LEO MSS secondary downlinks. Secondary services by definition shall not cause harmful interference nor claim protection from primary services.[146] This provision applies to protection of primary services from both in-band and out-of-band emissions and would apply to secondary MSS downlinks regardless of specified pfd levels. Thus, we see no reason to codify specific pfd limits as proposed in the Notice. We will instead modify proposed Section 25.213(a)(2) to note that secondary MSS downlinks shall not cause harmful interference to primary RAS operations in the 1610.6-1613.8 MHz band. Further, operators of secondary downlinks will be required to take whatever steps necessary to resolve interference complaints by radio astronomers. We expect that an applicant proposing to operate MSS downlinks in the 1613.8 - 1626.5 MHz band will be able to demonstrate in its application that it has sufficient satellite out-of-band emission attenuation to protect adjacent band U.S. RAS operations based upon the frequency separation inherent in the frequency assignment scheme adopted here.

118. Finally, Cornell University, Arecibo Observatory, notes its concern that MSS downlink transmissions at 1.6 GHz could have a "disastrous effect" on passive space research in the 1610-1667 MHz band.[147] LQP, in support of Cornell, notes that the Commission must limit MSS downlink transmissions to the 5.15 MHz proposed in the Commission's Notice, that is, to 1621.35-1626.5 MHz.[148] Motorola responds that "the 1613.8-1660 MHz band is not allocated to the RAS on a primary or secondary basis" and thus is not entitled to protection from secondary MSS downlinks operating outside that band.[149]

119. There is no RAS allocation in the 1613.8-1660 MHz band and the service is therefore not entitled to protection in these bands Consequently, we will not limit MSS transmissions in order to protect RAS as suggested by Cornell University and LQP. In any case, we do not believe that RAS observations above 1634 MHz would be affected by secondary MSS downlinks in the 1621.35-1626.50 MHz band given the frequency separation.

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[145] TRW Reply Comments at 74.

[146] See note 21, supra.

[147] Cornell Comments at 3-5. The 1610-1667 MHz band is being used passively, without any allocation, by radio astronomers to observe red-shifted Hydroxyl (OH) emissions.

[148] LQP Reply Comments at 59.

[149] Motorola Reply Comments at 49

d. Spurious emissions into the 4990-5000 MHz from primary downlinks in the 2483.5-2500 MHz band

120. The Committee recognized that second harmonic spurious emissions from primary MSS downlink transmissions in the 2483.5-2500 MHz band could cause unacceptable interference to RAS operations in the 4990-5000 MHz band. It concluded and we proposed in Section 25.213(a)(3) that MSS downlink out-of-band spectral power flux density (spfd) levels should be limited to -241 dB(W/m$^2$/Hz) in the 4990-5000 MHz band.

121. We will adopt the rules as proposed. Although Constellation argues that it opposes any such codification of the radio astronomy community's definition of "unacceptable" interference,[150] we note that Constellation participated in the Committee and its deliberations and agreed to the Committee's Report that included this recommendation. More importantly, as stated in the Notice, we believe that these limits can be readily met through proper amplifier device selection and operating conditions in combination with post-amplifier filtering.

2. Aeronautical Radionavigation Satellite Service and Radionavigation-Satellite Service

122. The U.S. Global Positioning System (GPS) can operate under the radionavigation-satellite (space-to-Earth) service (RNSS) allocation in the 1565.2-1585.6 MHz band. GPS is a space-based positioning, velocity, and time system whose space segment, when fully operational, will be composed of 21 operational satellites in six orbital planes. GLONASS, the Russian Global Navigation Satellite System, can operate under the same service allocation in the 1597-1610 MHz bands.[151] Additionally, GLONASS can operate under the aeronautical radionavigation service (ARNS) allocation in the 1610-1616 MHz band pursuant to RR 732 of the international Radio Regulations.[152] The GLONASS system will include 24 operational satellites in three orbital planes. The user segment of both the GPS and GLONASS systems will consist of antennas and receiver-processors that can receive both GPS and GLONASS signals to provide positioning, velocity, and precise timing to the user. The Committee addressed ARNS/RNSS - MSS sharing and developed specific recommendations in that regard. We based the sharing proposals in the Notice on the Committee's recommendations and on requirements embodied in the International Radio Regulations.

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[150] Constellation Comments at 48.

[151] See Notice, note 2, supra, at para. 53.

[152] RR 732 reserves the 1610-1626.5 MHz band on a worldwide basis for the use and development of air navigation and directly associated terrestrial or satellite based facilities. It also provides that any satellite use of the band is subject to agreement under the procedures of Article 14 of the International Radio Regulations. Pursuant to the international Radio Regulations, MSS stations may not cause harmful interference to or claim protection from stations operating in accordance with RR 731E.

a. In-band interference to ARNS from MSS uplinks in the 1610-1626.5 MHz band

123. Pursuant to international Radio Regulations, MSS stations may not cause harmful interference to or claim protection from stations operating under RR 732. Further, international Radio Regulation RR 731F provides that MSS earth stations operating with MSS space stations cannot radiate an equivalent isotropically radiated power (e.i.r.p.) density greater than -15 dB(W/4KHz) in that portion of the band used by systems operating in accordance with RR 732, and -3 dB(W/4KHz) in bands not so used.

124. The Committee concluded that GLONASS receivers operating on-board high altitude aircraft could be protected against interference from MSS operations operating in accordance with RR 731E.[153]. It also concluded that protection would not be possible if GLONASS is used for aircraft approach and terminal communications, as is contemplated by the FAA.[154] The Committee recommended and we proposed in Section 25.213(c)(1) to codify the uplink e.i.r.p. limits contained in RR 731E. The Committee had stated that this limit is needed to allow the proposed Big LEO systems to be implemented, although it acknowledged that it will not protect GLONASS if GLONASS is used to provide aircraft approach and terminal communications as a component of a "sole means" GNSS. The Committee also examined several methods to improve the ARNS/RNSS - MSS sharing environment. One was to reconfigure GLONASS so that it would operate only on frequencies below 1610 MHz.[155] Another method

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[153] The Committee analyzed the potential levels of interference from a typical CDMA mobile unit to a GPS/GLONASS receiver. It concluded that MSS units would not interfere with enroute GLONASS navigation at altitudes in excess of 10,000 meters (Committee Report, note 23, supra, at 3.3.4.3). However, aviation parties participating in the Committee stated that the analysis was inadequate to demonstrate interference compatibility at a 95 percent confidence level.

[154] See para. 49, supra. For a further discussion of the disparity between ARNS protection requirements and MSS user terminal e.i.r.p. requirements, see Committee Report, note 23, supra at 18-21.

[155] The Committee offered two possible methods for limiting GLONASS operations to frequencies below 1610 MHz. One would be to reconfigure the GLONASS frequency plan. Currently, the plan is for a total of 24 GLONASS satellites to operate using 24 discrete downlink carrier frequencies. However, GLONASS satellites currently under construction have the ability to operate on any of the 24 frequencies distributed between 1602 and 1615.5 MHz. This frequency agility could allow antipodal satellites (those above opposite areas of the earth) to operate using the same frequencies. Thus, the entire system could operate using 12 frequencies below 1610 MHz. The other method would be to shift all 24 GLONASS frequencies to spectrum below 1610 MHz. The Committee noted, however, that this more radical approach might require redesign of the GLONASS system. In any event, both the aviation community and the Big LEO community have indicated that they fully expect GLONASS to shift to frequencies below 1610 MHz at some point. The recent bilateral coordination meetings with the Russian Federation have confirmed that the GLONASS system will shift its frequencies to below 1606 by 2005 or sooner.

for improving sharing possibilities, it noted, would be to modify GLONASS receiver standards to reduce vulnerability to interference from in-band MSS. Alternatively, it suggested that the U.S. GPS be enhanced to lessen or eliminate reliance on GLONASS altogether. Further, the Committee recommended, and we proposed in Section 25.213(c)(2), that to protect operations of GLONASS receivers on-board aircraft, MSS terminals should be prohibited from being used on civil aircraft.

125. Aeronautical Radio, Inc., and the Air Transport Association of America (ARINC/ATA), Rockwell International Corporation (Rockwell), and the FAA argue that both GLONASS and GPS operations, as potential components of the GNSS, must be protected during all phases of flight over the United States. To that end, they proffer additional limitations on Big LEO operations. ARINC/ATA argues that the Commission should clarify that the RR 731E limitation of -15 dB (W/4kHz) for MSS mobile terminals should apply only after GLONASS moves to frequencies below 1610 MHz. Until then, they contend, the limit should be -78.5 dB (W/MHz).[156] Similarly, Rockwell states that the RR 731E limit is insufficient for protecting GLONASS operations at 1610-1616 MHz. Rockwell claims that the RR 731E power density level is about 140 dB above the maximum interference level that can be tolerated by a typical GLONASS receiving system. Rockwell asserts that shared use of this band segment is impractical absent significant constraints on either MSS or GLONASS. Therefore, it maintains that MSS operation should not be permitted in the 1610-1616 MHz band segment until GLONASS operations are shifted to frequencies below 1610 MHz.[157] The FAA states that the Commission indicated that use of the 1610-1616 MHz band by MSS is premised upon moving GLONASS below 1610 MHz. It maintains that the e.i.r.p. density specified in RR 731E is too high to protect in-band GLONASS for anything but high altitude enroute communications.[158]

126. Several of the MSS applicants also disagree that more restrictive limits should be placed on MSS uplinks pending a GLONASS frequency shift. Constellation states that more realistic interference criteria and models must be developed before any requirements other than the RR 731E uplink e.i.r.p density limit can be adopted.[159] Ellipsat contends that no additional requirements should be adopted because the aviation community has not provided a legitimate basis for overly stringent requirements on MSS uplinks. Further, Ellipsat maintains that even if GLONASS becomes a component of the GNSS, the aviation community has not provided a showing that GNSS performance would be impaired if degradation were to occur to the small number of GLONASS satellites that would operate above 1610 MHz.[160] Motorola claims that

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[156] ARINC/ATA Comments at 2-3.

[157] Rockwell Comments at 2-3.

[158] FAA Comments at 2.

[159] Constellation Reply Comments at 47.

[160] Ellipsat Reply at 11.

the proposed limits advocated by the aviation community are based on flawed assumptions and unsound analysis. Additionally, Motorola asserts that the protection the aviation parties claim as necessary is based on the erroneous assumption that corrupting a single measurement from a GLONASS satellite will cause unacceptable degradation in the ability to navigate.[161]

127. Several MSS applicants also state that, to afford new MSS systems flexibility in how they protect ARNS/RNSS, the Commission should modify proposed rule Section 25.213(c)(1), which, in addition to the uplink limits contained in RR 731F, requires all MSS operations in the 1.6 GHz band to be coordinated with systems operating pursuant to RR 732. Motorola argues that rules embodied in the international Radio Regulations are adequate for ensuring coordination with and protection of other services.[162] Constellation contends that footnote RR 731E establishes the only enforceable interference criteria (i.e., a maximum e.i.r.p. density of -15 dB (W/4kHz) from MSS transmitters) that can be incorporated into the Commission's rules at this time. Motorola, in contrast, suggests that the e.i.r.p value set forth in Section 25.213(c)(1) be interpreted as a coordination trigger rather than an absolute limit.[163] LQP states that the proposed rule requires MSS systems to protect GLONASS beyond the limits specified in RR 731E.[164]

128. We do not believe it is necessary to protect GLONASS operations beyond the provisions of RR 731E and the obligation to coordinate MSS systems under current International Telecommunications Union (ITU) procedures. RR 731E states clearly that MSS stations shall not cause interference to, nor claim protection from ARNS stations operating in accordance with RR 732. In addition, under ITU Resolution 46, Big LEO licensees would be subject to whatever limits or conditions agreed upon during the coordination process. GLONASS would likely be part of the coordination negotiations. Accordingly, we reject the aviation community's requests that additional limits be placed on MSS operations pending a GLONASS move, particularly absent definitive technical characteristics and requirements of a future GNSS system, and a

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[161] Motorola Reply Comments at 51. Motorola notes that a study conducted for LQP by Sat-Tech Systems demonstrates that loss of a single satellite will never cause a loss of GNSS (LQP Comments at Technical Appendix, para. 2.2.1 at 12). In addition, the Committee performed an analysis of the availability of GNSS satellites if the GLONASS constellation operated only on frequencies below 1610 MHz. It concluded that a minimum of five satellites would always be available for GNSS. In addition, it noted that this minimum would occur for only 14 minutes in every 51-day period. It noted further that since only four GNSS satellites are required for navigation and an additional one satellite to for system integrity, it appeared that GLONASS satellites operating above 1610 MHz might not be required for either navigation or terminal approach communications. Committee Report, note 23, supra at 3.3.4.4.

[162] Motorola Reply Comments at 47.

[163] Motorola Comments at 55.

[164] LQP Comments at 66-67.